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Umbilical Cord Colonization and the Optimal Method of its Disinfection

INAUGURALDISSERTATION ZUR ERLANGUNG
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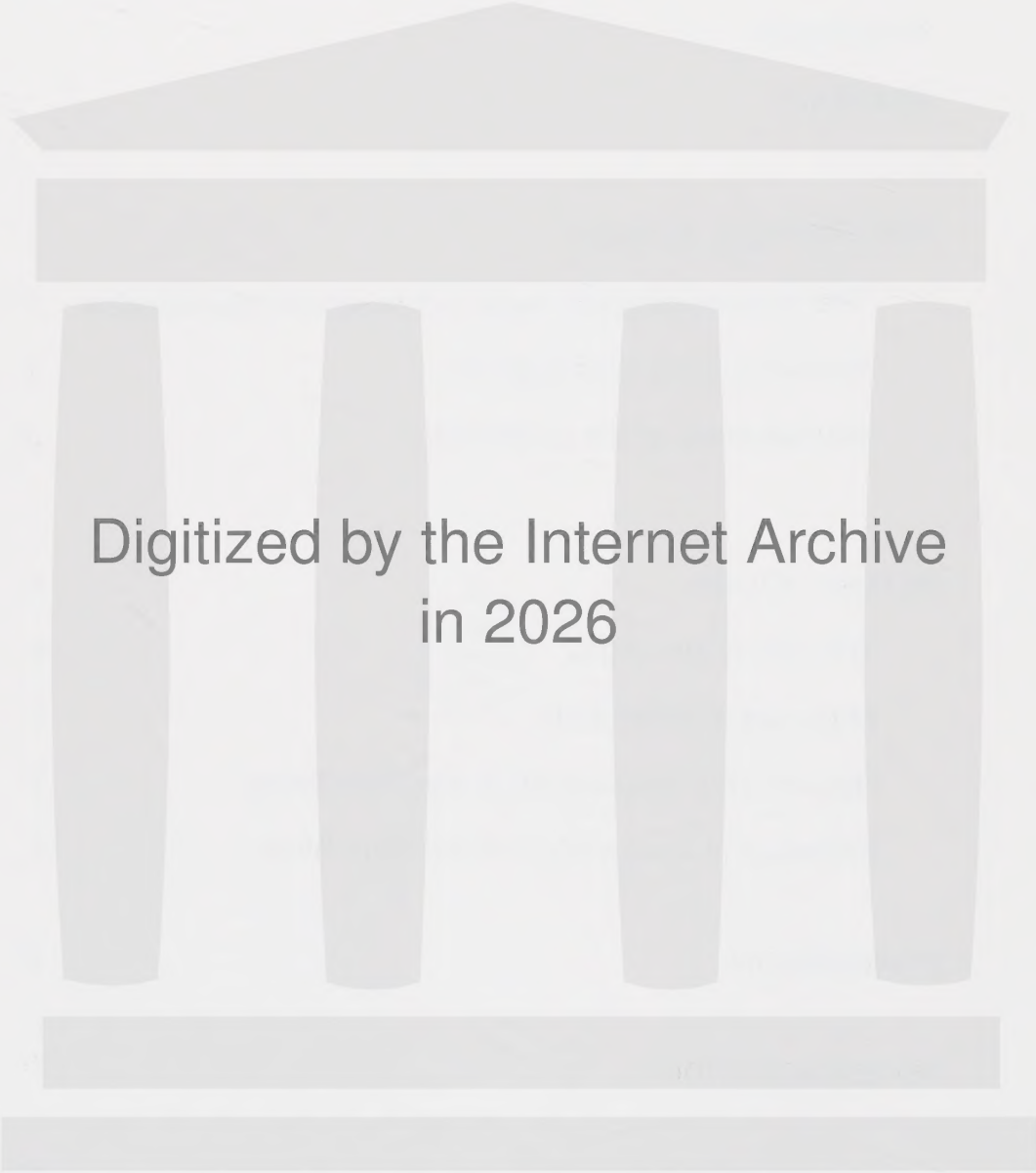
Genehmigt auf Antrag von Prof. Dr. G. Duc

— Zürich 1981 —



CONTENTS

	page
FOREWORD	
ABSTRACT	
THEORETICAL SURVEY	1
The Epidemiological Aspect of Newborn Colonization	1
Umbilical Cord Colonization	2
Management of the Umbilicus	3
ACTUAL STUDY	4
The Aim of the Study	4
Materials and Methods	4
Results and Discussions of the Pilot Study	7
Results and Discussions of the Main Study	10
CONCLUSION	19
REFERENCE INDEX	20
CURRICULUM VITAE	22



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FOREWORD

During the year 1979 I was a visiting doctor at the pediatric hospital and in the neonatal unit of the Department of Gynaecology and Obstetrics of the University of Zürich. Thanks to the fast and constant development in the field of Neonatology, its special neonatology section arouses much scientific and clinical interest. The work performed by the team of this unit is most attracting for every doctor in my situation, particularly the detailed and interesting discussions of every problem related to newborns.

I have chosen as a subject for the present work the problem of the disinfection of the umbilical stump of the newborn infant. The study involved 230 newborns whose over 300 bacterial cultures from the umbilicus were set in.

I wish to thank the working teams in the delivery rooms, in the maternity unit and in the laboratory; only with their cooperation and efforts it was possible to accomplish this dissertation.

A. Ismail

ABSTRACT

The problem of bacterial colonization of the umbilical stump of the newborn and the optimal method of its disinfection was studied among 230 newborns. 3 common disinfection preparations (Mercurochrome, salicylic acid powder and Triple dye) were tested. Each preparation was applied on the umbilical stumps of 50 newborns (3 times a day). Another 50 newborns receiving no local disinfection were considered as control group.

Staph. aureus, *staph. albus*, *e. coli* and enterococci constitute the main bacterial flora on the umbilical stump of the infants in our nursery. Most of them, especially *staph. aureus*, appear within the first 24 hours of life.

Triple dye is more effective than mercurochrom and salicyl powder in reducing all of these common microorganismus. We demonstrated the impressive effect of multiple application of this preparation in reducing *staph. aureus* and *e. coli* colonization. The *staph. aureus* colonization rate was reduced from 52 to 8% with no incidence (0%) of the richly colonized umbilicus (+++). This corresponds to 22% and 18% for mercurochrom and salicyl powder respectively. It also reduced our low colonization rate of haemolytic streptococci Group B from 8% to 0%. Triple dye has no effect on gram negative enterobacteria and klebsiella but these are minor residents on the umbilicus of our infants.

Salicylic acid powder also has a wide spectrum of activity, although not as impressive as triple dye. With salicyl powder the remnants of the umbilicus disappeared the fastest.

THEORETICAL SURVEY

The Epidemiological Aspect of Newborn Colonization

The human fetus in utero is bacteriologically sterile as evidenced by the negative bacterial cultures obtained at time of elective cesarean section. Colonization begins at the moment of birth (2, 16).

The mother, other adults or older infants in the nursery are the original sources from which the newborn derives its microbial flora. Microorganism can be transmitted to the newborn via air, fomites and hands of hospital personnel. The relative importance of these various routes of transmission is determined by the obstetrical nursing procedures and the infectiousness of the microorganism.

By the end of the first or second week, the infant body has acquired most of the microorganism found on corresponding areas of the adults with few exceptions. These exceptions include the frequent presence of coliforms and staph. aureus in the infant throat, the predominance of lactobacillus bifidus in the lower intestine of the breast fed infants and the frequent presence of large numbers of staph. aureus on the skin and in the rectum (11).

Colonization of the newborn normally begins in the groin or on the umbilical cord, but other skin areas may also become first colonized like the nose and throat. Such observations on the sequence of colonization were made by Hurst (11), who

obtained daily cultures from various body sites of 360 newborns in two different hospitals where dry skin care was being practiced. It was noticed that the skin was often colonized before the cord and the nose, particularly the groin.

Umbilical Cord Colonization

The necrotic tissue of the remnants of the umbilical cord is a favorable medium for bacterial multiplication. Infection of the umbilicus due to streptococcus pyogenes and staph. aureus was a major cause of neonatal death 20 years ago (4).

Although omphalitis is now rarely seen in modern nurseries, the umbilical stump still becomes colonized by pathogenic bacteria. Staph. aureus is the predominant microorganism, but what are also likely to appear are st. epidermidis, haemolytic streptococci, strept. pyogenes, coliform, proteus sp., pseudomonas sp., and yeast (8, 14).

Since such colonization seldom results in omphalitis, recent concern has been caused mainly by the role of the cord as a reservoir for nursery acquired infections, especially due to staph. aureus and haemolytic streptococci. The importance of cord colonization was first noticed in 1956 in two hospitals in Britain where an outbreak of streptococcus infection took place. Puerperal sepsis occurred among mothers and tonsillitis became prevalent among nursery personnel. The infants remained asymptomatic, although streptococci were cultured in their cord stumps (13).

Jellard (12) pointed out the importance of the cord as a reser-

voir for staphylococci infections and demonstrated by serial cultures from different body sites that the newborn's umbilical cord was often colonized by staph. aureus before the nose. She showed that treating the cord with bacteriostatic dyes reduced the incidence of staphylococcal colonization.

Although Jellard was not the first to notice proliferation of staph. aureus on the infant cord, earlier investigators had apparently assumed that this was secondary to thaht of the nose. Other investigators confirm the findings of Jellard (9, 15).

Rapid colonization of the cord may be mainly a hospital phenomenon. One study (7) found that only 9% of the infants born at home had staph. aureus on the umbilicus at the eighth day of life.

Management of the Umbilicus

The optimum method of managing the umbilicus has not yet been defined. Many different measures have been used for treating the umbilical stump in a way to avoid local infection and to reduce the incidence of colonization by pathogenic bacteria and so to reduce its spread to other sites of the body and possibly the environment.

Studies be Jellard (12), Bernstine (3), Huntingford (10) and Cook (5) recommend ligation of the cord, avoidance of handling and possible use of an appropriate sterile dressing to prevent contamination. In addition, the repeated application of a preparation with properties that impair bacterial proliferation are of value.

ACTUAL STUDY

The aim of the study is to determine the effectiveness of different preparations in reducing colonization of the umbilical stump by pathogenic bacteria and in reaching its quickest falling-off.

Materials and Methods

Between May and December 1979, 230 newborns, products of a normal delivery without adaption troubles, receiving no antibiotics, were selected for the study. All of them were partially roomed with their mothers and had a routine general care. Infants who spent any time in the intensive care unit were excluded from the study.

The umbilical care regimen during the study consisted of instrumental ligation by plastic clamp and application of a sterile dressing to the cord for the first two days; in addition to the multiple application of a local disinfectant (3 times a day) to the umbilical area during their «one week stay» in the nursery. On the fifth day of life, all infants were examined for the presence or absence of the umbilical stump and for its dryness at the ground and shaft by a physician not involved in the study.

The study was conducted in the subsequent forms: a pilot study among 30 newborns and a main study with 200 newborns.

In the **pilot study** there were 3 groups, each containing 10 new-

borns who received one of the following preparations for umbilical disinfection:

1. Mercurochrom (2 % merbromin, 98 % distilled water)
2. Salicyl powder (3 % salicylic acid, 97 % sterile sucrose)
3. Alcohol (80 %).

Cultures were taken 3 times from the umbilical stump of each newborn:

- a) A swab immediately after delivery (0—10 minutes)
- b) A swab after 24 hours
- c) A cut disc biopsy from the free end of the umbilical stump on the 5th day of life — or a swab if the umbilical stump had fallen off.

In the **main study** (200 newborns) 3 preparations were tested on 4 groups, each containing 50 newborns. These were:

1. Triple dye (brilliant green 2.29 mg/ml, proflavin hemisulfate 1.14 mg/ml, and gentian violet 2.29 mg/ml)
2. Mercurochrom
3. Salicyl powder
4. No local disinfection (this group was considered as a control group).

Cultures were taken from the umbilical stump on the 3rd day of life in two forms: a swab and a cut disc biopsy.

Swabs were transported to the laboratory in transport-media*) and biopsies were transported in sterile doses. In the laboratory both were liquified and concentrated by «thioglycolate broth» and then cultured in sheep agar.

*) «Port-A-cul» tubes, product of Becton-Dickinson Co. U.S.A.

In determining the bacterial colonies that grow in the blood agar, the following methods were undertaken:

- Mac-conkey media were used for gram -ve bacterial cultures.
- CAMP-test for detection of haemolytic streptococci group B.
- Bacitracin test for haemolytic streptococci group A.
- Asculin fermentation for enterococci.
- Koagulase test for staphylococci.

In the quantitative measurement of bacteria, the following abbreviations were used:

- +++ indicate colonies in the range of 10^{5-7}
- ++ indicate colonies in the range of 10^4
- ± indicate colonies in the range of 10^3
- ± indicate colonies in the range of 10^2 or less

Results and Discussions of the Pilot Study

The following table shows bacterial colonization on the umbilical stump from 30 newborns under the application of different disinfectant substances (each one for 10 newborns).

substance	Mercurochrom			Salicyl powder			Alcohol		
age	0-10 min.	24 h.	5 days	0-10 min.	24 h.	5 days	0-10 min.	24 h.	5 days
Staph.aureus	0	4	7	2	4	2	1	5	7
E. coli	0	1	1	1	2	1	1	2	3
Staph. albus	4	2	7	4	5	6	8	0	0
Haem. SGB	1	2	0	1	1	1	0	0	0
Enterecocci	0	0	3	1	1	4	2	3	4
Strept. viridance	0	1	0	2	1	1	0	1	1
Coliform	0	0	1	1	0	0	0	1	6
Proteus mirabilis	0	0	1	0	0	1	1	0	1

Table 1

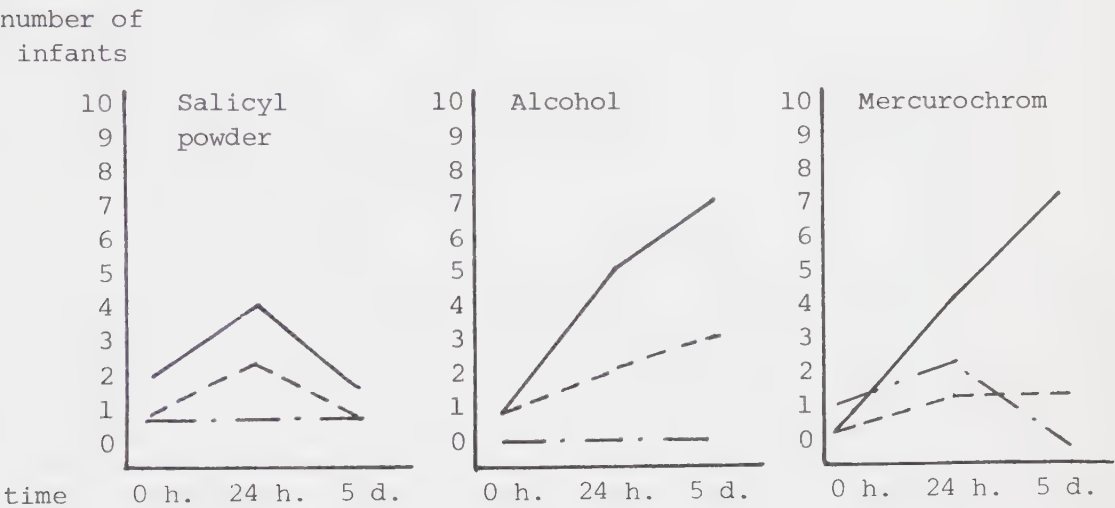
The next table shows the number of infants whose umbilical stumps have fallen off before the 5th day.

substance	number of infants whose umb.stump fell before the 5th day
Salicyl powder	6
Mercurochrom	4
Alcohol	0

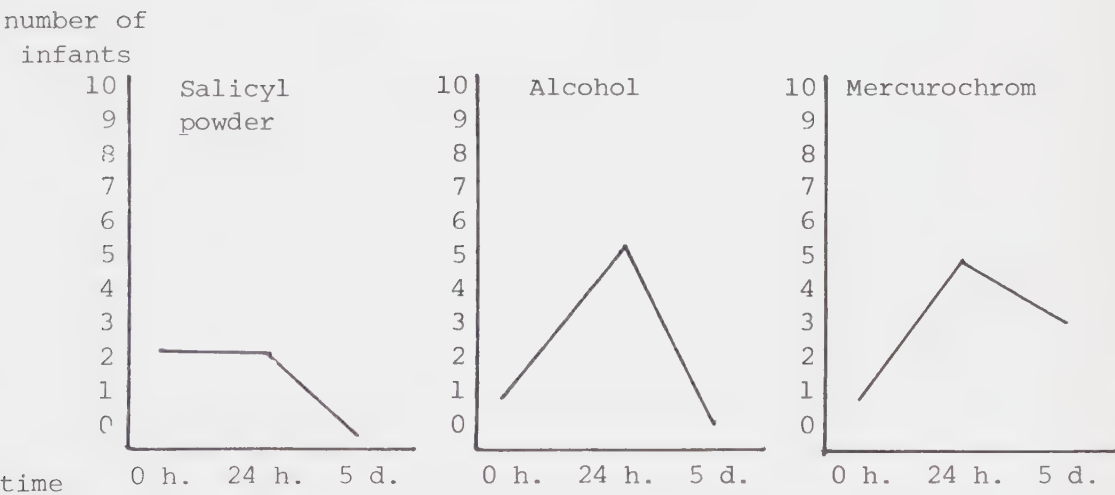
Table 2

The following diagram shows the prevalence of the common pathological bacteria on the umbilical stump.

- : staph. aureus
- : e. coli
- . - . : haem. strept. group B



Prevalence curve



Incidence curve for St. aureus

Incidence: new colonized cases
 Prevalence: total colonized cases
 Figure 1

With respect to the small number of infants (30 newborns) involved in this study, whose 90 cultural results are tabulated in table 1, we found that staph. aureus, e. coli, staph. albus and enterococci constitute the main flora on the umbilical stump.

From the 30 infants 10 % were already colonized 0—10 minutes after birth by staph. aureus, 52 % by staph. albus, 10 % by enterococci and 7 % by e. coli. This shows how fast colonization begins in this region and points out the mother's birth canal as a possible source of umbilical colonization.

A high incidence of colonization is reached within the first 24 hours, especially for staph. aureus which rose from 10 % immediately after birth to 42 % after 24 hours, then to 53 % on the fifth day (under local disinfection). This fast increase in the incidence applies less for other bacteria, where such rate is gradually increased as shown in figure 1. Such affinity of the newborn for staph. aureus colonization is still unexplained.

Salicyl powder and mercurochrom showed almost similar results, except that the former was relatively more effective against staph. aureus (only in the fifth day cultures). The umbilical stump fell off quicker with salicylic acid application (table 2).

Bacterial colonization was at the highest level among the 10 newborns who were treated with alcohol. Coliform and enterococci were especially flourishing. Only staph. albus disappeared under alcohol application. In all these infants, the umbilical stump fell off after the fifth day.

Haem. strept. group B was rarely cultured. Among the 90 cultures 6 grew this bacteria. Synergic and antagonistic effect between the different microorganisms was difficult to notice. An effect by birth weight or gestation at age or type of feeding on umbilical cord colonization was also not found. We believe that the studied number of cases is too small to prove such epidemiological phenomenon.

Results and Discussions of the Main Study

Umbilical colonization rate of common bacteria that grow from swabs

Bacteria	triple dye	Mercurochrom	Salicyl powder	No treat.
St. aureus	8 % <u>0 %</u>	22 % <u>8 %</u>	18 % <u>10 %</u>	52 % <u>32 %</u>
St. albus	32 % <u>2 %</u>	80 % <u>20 %</u>	54 % <u>24 %</u>	38 % <u>12 %</u>
E. coli	20 % <u>6 %</u>	36 % <u>10 %</u>	20 % <u>10 %</u>	44 % <u>24 %</u>
Enterococci	20 % <u>2 %</u>	46 % <u>14 %</u>	40 % <u>10 %</u>	24 % <u>12 %</u>
Haemolytic strept. GB.	0 % <u>0 %</u>	2 % <u>2 %</u>	4 % <u>2 %</u>	4 % <u>0 %</u>
no growth	12 %	0 %	2 %	0 %

Table 3

N.B.

Figures underlined are colonization rates at the high level (+++), other figures represent averages of the respective groups.

Umbilical colonization rate of common bacteria that grow from biopsies

Bacteria	triple dye	Mercurochrom	Salicyl powder	no treat.
St. aureus	10 % <u>4 %</u>	16 % <u>2 %</u>	14 % <u>2 %</u>	50 % <u>26 %</u>
St. albus	46 % <u>12 %</u>	82 % <u>18 %</u>	66 % <u>10 %</u>	54 % <u>16 %</u>
E. coli	22 % <u>6 %</u>	40 % <u>2 %</u>	26 % <u>0 %</u>	40 % <u>16 %</u>
Enterococci	22 % <u>2 %</u>	34 % <u>4 %</u>	38 % <u>2 %</u>	24 % <u>6 %</u>
Haemolytic strept. GB.	0 % <u>0 %</u>	2 % <u>2 %</u>	4 % <u>0 %</u>	8 % <u>0 %</u>
no growth	14 %	0 %	8 %	0 %

Table 4

Figures underlined are colonization rates at the high level
(+++),
other figures represent averages of the respective groups.

Description of the umbilicus on the 5th day

Substance	Absent umb. stump	Dryness at the ground	Dryness in presence of the stump ground shaft	
triply dye	0 %	42 %	42 %	82 %
Mercuro-chrom	8 %	25 %	0 %	35 %
Salicyl powder	18 %	40 %	30 %	48 %
no treat. *)	2 %	0 %	0 %	25 %

Table 5

*) In this group the umbilicus have had an offensive smell. No anaerobic cultures were set. This was not part of our program.

Quantitative and qualitative bacterial estimation in the swabs and biopsies under application of different disinfection substances

a)

Bacteria		Triple dye		Mercurochrom		Salicyl powder		no treat.	
		Swab Biopsy		Swab Biopsy		Swab Biopsy		Swab Biopsy	
St.aureus	+++	0 %	4 %	8 %	2 %	10 %	2 %	32 %	26 %
	++	4 %	6 %	10 %	12 %	6 %	6 %	14 %	16 %
	+	2 %	0 %	4 %	2 %	2 %	2 %	4 %	8 %
	<u>+</u>	2 %	0 %	0 %	0 %	0 %	4 %	0 %	0 %
St.albus	+++	2 %	12 %	20 %	18 %	24 %	10 %	12 %	16 %
	++	18 %	24 %	32 %	34 %	22 %	28 %	16 %	30 %
	+	2 %	8 %	10 %	10 %	8 %	24 %	10 %	8 %
	<u>+</u>	10 %	2 %	18 %	20 %	6 %	4 %	0 %	0 %
E. coli	+++	6 %	6 %	10 %	2 %	10 %	0 %	24 %	16 %
	++	6 %	6 %	16 %	12 %	4 %	4 %	8 %	16 %
	+	4 %	8 %	6 %	10 %	4 %	10 %	6 %	6 %
	<u>+</u>	4 %	2 %	4 %	16 %	2 %	12 %	6 %	2 %
Entero-cocci	+++	2 %	2 %	14 %	4 %	10 %	2 %	12 %	6 %
	++	6 %	10 %	10 %	14 %	20 %	16 %	2 %	0 %
	+	2 %	10 %	16 %	12 %	8 %	18 %	10 %	12 %
	<u>+</u>	10 %	0 %	6 %	4 %	2 %	2 %	0 %	6 %

b)

Bacteria		Triple dye		Mercurochrom		Salicyl powder		no treat.	
		Swab Biopsy		Swab Biopsy		Swab Biopsy		Swab Biopsy	
Strept. viridance	+++	0 %	0 %	0 %	2 %	0 %	0 %	2 %	2 %
	++	0 %	0 %	12 %	0 %	8 %	8 %	8 %	0 %
	+	2 %	0 %	0 %	2 %	6 %	4 %	6 %	2 %
	<u>+</u>	0 %	2 %	6 %	6 %	0 %	2 %	2 %	0 %
Klebselle	+++	2 %	0 %	0 %	0 %	4 %	0 %	0 %	0 %
	++	8 %	6 %	2 %	0 %	2 %	4 %	2 %	2 %
	+	2 %	6 %	0 %	0 %	2 %	2 %	4 %	0 %
	<u>+</u>	2 %	2 %	0 %	2 %	0 %	0 %	0 %	4 %
Entero- bact.	+++	6 %	6 %	0 %	0 %	2 %	2 %	0 %	0 %
	++	4 %	4 %	2 %	2 %	0 %	0 %	12 %	4 %
	+	2 %	4 %	2 %	4 %	0 %	0 %	4 %	4 %
	<u>+</u>	2 %	2 %	0 %	4 %	0 %	0 %	0 %	2 %
Proteus marbil.	+++	0 %	0 %	2 %	2 %	0 %	0 %	4 %	4 %
	++	2 %	2 %	0 %	0 %	0 %	0 %	2 %	2 %
	+	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
	<u>+</u>	0 %	0 %	0 %	0 %	0 %	2 %	0 %	2 %

c)

Bacteria		Triple dye		Mercurochrom		Salicyl powder		no treat.	
		Swab Biopsy		Swab Biopsy		Swab Biopsy		Swab Biopsy	
Haemolytic streptococci GB.	+++	0 %	0 %	2 %	2 %	2 %	0 %	0 %	2 %
	++	0 %	0 %	0 %	0 %	2 %	4 %	4 %	2 %
	+	0 %	0 %	0 %	0 %	0 %	0 %	0 %	4 %
	<u>+</u>	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Corny-bacteria	+++	0 %	0 %	0 %	0 %	0 %	0 %	0 %	2 %
	++	0 %	0 %	0 %	0 %	0 %	0 %	10 %	4 %
	+	2 %	0 %	0 %	0 %	0 %	0 %	4 %	4 %
	<u>+</u>	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Citrobact-diversus	+++	2 %	2 %	0 %	0 %	0 %	0 %	2 %	0 %
	++	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
	+	0 %	0 %	0 %	2 %	0 %	0 %	0 %	2 %
	<u>+</u>	0 %	0 %	2 %	0 %	0 %	0 %	0 %	0 %
no growth		12 %	14 %	0 %	0 %	2 %	8 %	0 %	0 %

Table 6

Bacteria that grew in only one of all 200 newborns are Neisserien, citrobacteria fundii, proteus vulgaris (in 2 infants), coliform, bacilli cireus and pseudomonas aeruginosa.

Most of the microorganisms which grow in this region were at their highest level among the control group which received no preparation, especially staph. aureus and e. coli; besides the bad offensive smell, the delayed disappearance of the umbilical stump and the possibility of infection were noticed.

The most common microorganisms which grow from the umbilicus are staph. aureus, staph. albus, and e. coli. These bacteria constituted 70 % of sepsis cases in our intensive care unit during the same year. Staph. aureus alone amounted to 20 %. This arises the question of the cord as possible source for bacterial infection.

We can classify the bacterial flora in the umbilicus of our newborns into:

1. the most common bacteria; these are staph. aureus, staph. albus, enterococci, and e. coli.
2. less common bacteria like streptococci viridance, enterobacteria and klebsiella.
3. rare bacteria like proteus marbilis, cornyacteria, haemolytic streptococci Group B and citrobacteria diversus.

Triple dye was significantly more effective than both salicylic acid powder and mercurochrom in reducing all of the common bacteria (staph. aureus, staph. albus, enterococci and e. coli) as shown in table 3. Especially the staph. aureus colonization rate was reduced to 8 % with no incidence (0 %) of the richly colonized umbilicus (+++). In comparison, mercurochrom reduced staph. aureus colonization to 22 % and salicyl powder to 18 %. This is the case in swab cultures which also applies, but less clearly, for biopsies, where 10 % developed staph. aureus under triple dye, 16 % under mercurochrom and 14 % under salicyl powder respectively.

The umbilicus was kept relatively dry under triple dye. The shaft of the umbilical stump was dry in 82 % and the umbilical ground in 42 % on the 5th day of life. This is an advantage for triple dye because wetness was common with salicyl powder and mercurochrom as shown in table 5. This wetness is supposed to enhance bacterial proliferation while dryness and acidity are known factors that prevent colonization of many bacteria on the healthy skin.

Although triple dye was effective against enterococci only at the high levels of colonization (+++, ++, +) compared to the control group, this bacteria was found at a much higher rate under salicyl powder and mercurochrom, namely 40 % and 46 % respectively, compared to 24 % in the control group.

Triple dye has one of the most potent antibacterial effects against streptococcus viridans and corny bacteria. We were not in a position to demonstrate the effect of these preparations on haemolytic streptococcus Group B. This bacteria was rarely cultured among our infants even in the control group as shown in tables 3 and 4. Still, an effect of triple dye could be suggested. Haemolytic streptococcus Group B, in spite of its rarity on the umbilical stump, constitutes about 20 % of the sepsis cases in our intensive care unit and its high occurrence raises the question of its source and preventive measures. It was found only in 3.5 % on the umbilicus of the total of 200 infants. A high rate of exogenous introduction may be the overwhelming factor.

Another sensitive parameter in the study which indicates the impressive effect of triple dye is the absence of any bacteria in 12 % of swabs and 14 % of biopsies where it was used. This corresponds to 0 % and 2 % of swabs for mercurochrom and salicyl powder respectively, and 0 % and 8 % of their biopsies.

Triple dye was found to have no effect on gram negative enterobacteria or klebsiella, compared to the control group; the latter was even found in a higher rate (see table 6). With this dye, shriveling of the umbilical cord was delayed as shown in table 5. Another disadvantage of the use of triple dye is the difficulty of applying an umbilical catheter because of the extreme and quick dryness accompanying its use.

Although not as impressive as triple dye, salicyl powder is a more favourable antiseptic than mercurochrom against all of the most common microorganisms, namely against staph. aureus, e. coli and enterococci as shown in table 3. It reduced the overall colonization rate of staph. aureus and e. coli to 18 % and 20 %, compared to 22 % and 36 % with mercurochrom. The difference in staph. albus and enterococci colonization with the application of these two substances is 54 % and 40 % for salicyl powder, corresponding to 80 % and 46 % for mercurochrom. For both preparations these rates are higher than in the control group, where nothing was used. The above mentioned differences in swab cultures apply also more or less for biopsies as shown in table 4. Against gram negative enterobacteria salicyl powder was more effective than both triple dye and mercurochrom. The fastest disappearance of the remnants of the umbilicus was reached with this powder form. On the 5th day of life, 18 % of the infants tested were already without an umbilical stump, compared to 8 % treated with mercurochrom and 0 % with triple dye.

These results confirm the findings of Wald et al (19) and other investigators (6, 17, 18). We were unable to demonstrate bacterial antagonism suggested by Speck et al (18). He also found that triple dye enhances the growth of haemolytic streptococci. In our study the contrary was the case: Triple dye also reduced the growth of haemolytic streptococcus Group B. He used non-

selective media for this microorganism which may account for the different data. Through multiple application of triple dye we reached a more significant reduction of bacterial colonization than with single application as performed in another study (Barrett et al (1).

CONCLUSION

Staph. aureus, *staph. albus*, *e. coli* and enterococci constitute the main bacterial flora on the umbilical stump of the infants in our nursery. Most of them, especially *staph. aureus*, appear within the first 24 hours of life.

Triple dye is more effective than mercurochrom and salicyl powder in reducing all of these common microorganisms. We demonstrated the impressive effect of multiple application of this preparation in reducing *staph. aureus* and *e. coli* colonization. The *staph. aureus* colonization rate was reduced from 52 to 8 % with no incidence (0 %) of the richly colonized umbilicus (+++). This corresponds to 22 % and 18 % for mercurochrom and salicyl powder respectively. It also reduced our low colonization rate of haemolytic streptococci Group B from 8 % to 0 %. Triple dye has no effect on gram negative enterobacteria and *klebsiella* but these are minor residents on the umbilicus of our infants.

Salicylic acid powder also has a wide spectrum of activity, although not as impressive as triple dye. With salicyl powder the remnants of the umbilicus disappeared the fastest.

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